

the element under consideration may be found by direct integration, supposing the elements to be constant in the terms to be integrated, and the mean longitudes only to vary. Also the secular variation of the element considered, that is, the rate of variation of the element when cleared of periodic inequalities, will be given by the secular terms taken alone. If the disturbing masses, however, are not very small, this process is not sufficiently accurate, and the periodic inequalities thus found can only be regarded as a first approximation to the true values. In order to find more correct values, we must substitute for the elements in the second member of the equation their secular parts augmented by the approximate periodic inequalities before found.

Now, if in any periodic term we increase any element by a periodic inequality depending on a different argument, that is, involving different multiples of the mean longitudes, the result will evidently be to introduce new periodic terms which will involve the square of one of the masses or the product of two of them as a factor. Similarly, if in any periodic term any element be increased by a periodic inequality depending on the same argument, the result will also introduce new terms of the second order which do not involve the mean longitudes, and which therefore constitute new secular terms. These will be particularly important if the inequality in question be one of long period. Also in the secular terms the result of increasing any element by a periodic inequality will be to introduce a new periodic term depending on the same argument. Lastly, it should be remarked that in finding the periodic inequalities of any element by integration of the corresponding differential equation, we must take into account the secular variations of the elements which were neglected in the first approximation. The new terms thus introduced, like the others which we have just described, will evidently be of the second order with respect to the masses.

If the disturbing masses be large, as in the case of the mutual disturbances of Jupiter and Saturn, it may be necessary to proceed to a further approximation, and thus to obtain new terms, both periodic and secular, which involve the cubes and products of three dimensions of the masses. The number of combinations of terms which give rise to these terms of the second and third orders is practically unlimited, and the art of the calculator consists in selecting those combinations only which lead to sensible results. This is the chief cause of the great complexity of the theories of the larger planets, and more especially of those of Jupiter and Saturn.

M. Leverrier lays it down as the indispensable condition of all progress that we should be able to compare the whole of the observations of a planet with one and the same theory, however great may be the length of time over which the observations extend. In order to satisfy this condition, he develops the whole of his formulæ algebraically, leaving in a general symbolical form all the elements which vary with the time, such as the eccentricities, the inclinations, and the longitudes of the perihelia and nodes. He treats in the same way the masses which are not yet sufficiently known.

All the work is given in full detail, and is divided as far as possible into parts independent of each other, so that any part may be readily verified. All the terms which are taken into account are clearly defined, so that if it should ever be necessary to carry on the approximations still further, it will be easy to do so without having to begin the investigation afresh. The whole work is presented with such clearness and method as to make it an admirable model for all similar researches.

After the development of the disturbing functions, and the formation of the differential equations on which the variations of the elements depend, the first step to be taken is to determine by integration of these equations the periodic inequalities of the elements of the orbits of

Jupiter and Saturn which are of the first order with respect to the masses. As we have already said, the expressions of these periodic variations of the elements are given with such generality that, in order to obtain their numerical values at any epoch whatever, it is sufficient to substitute the secular values of the elements at that epoch. The calculation of the various terms under this general form is very laborious, and it requires great and sustained attention in order to avoid any error or omission of importance. On the other hand, by substituting from the beginning the numerical values of the elements at a given epoch, the calculation is rendered much shorter and admits much more readily of verification; but the result thus obtained only holds good for the given epoch, and is thus entirely wanting in generality.

In the determination of the long inequalities of Jupiter and Saturn, the approximation is carried to terms which are of the seventh degree with respect to the eccentricities and the mutual inclination of the orbits. In the next place the terms of the first order in the secular variations of the elements of the orbits are determined. After this the periodic inequalities of the second order with respect to the masses are considered. These are determined in the same form as the terms of the first order, in order that their expressions may hold good for any epoch whatever. The formulæ relating to these terms are necessarily very complicated. The coefficient belonging to a given argument depends, in general, on a great number of terms which are classed methodically. Next are determined the terms of the second order in the secular variations of the elements of the orbits. Afterwards, M. Leverrier takes into account the influence of the secular inequalities on the values of the integrals on which the periodic inequalities depend. The last part of this chapter is devoted to the completion of the differential expressions of the secular inequalities by the determination of certain secular terms in the rates of variation of the eccentricities and the longitudes of the perihelia, which are of the third and fourth orders with respect to the masses.

(To be continued.)

## NOTES

WE record with sincere regret the death of Prof. Alphonse Oppenheim, at Hastings, on the 17th inst.; he died by his own hand through grief at the death of his wife. Prof. Oppenheim is well known for his numerous researches in organic chemistry. Formerly one of the professors of chemistry at the University of Berlin, he only a few months ago, as we recorded at the time, had accepted the chair of chemistry at the University of Münster, in Westphalia. Prof. Oppenheim was a frequent contributor to this journal, and was much esteemed by a large circle of friends in England.

THE death is announced, on the 17th inst., at the age of seventy-seven, of Mr. W. H. Fox Talbot, F.R.S., the inventor of the photographic process known as Talbotype, a name latterly merged in the general name photography. Mr. Talbot was a man of varied attainments and manifold work. He was educated at Harrow and Cambridge, where he distinguished himself as a Greek scholar. He took a delight in chemistry, and it was in 1833 that he seems to have conceived the idea of inventing some process by which the beautiful pictures exhibited in a camera lucida could be impressed and rendered permanent. He and Daguerre seem to have brought their several processes to a satisfactory result almost simultaneously, though Daguerre was the first to announce his process, in 1839. Mr. Talbot lost no time in communicating to the Royal Society the details of his own process, though it was not till 1840 that he made the discovery which "laid the foundation of the photographic art in its present form." In 1842 Mr. Talbot was presented with the gold medal of the Royal Society. He did not patent his discovery, but on

account of its great value and many uses, freely gave the benefit of it to the public. In subsequent years Mr. Talbot published various modifications and applications of his process, but latterly he had turned his attention to quite a different field, publishing various works on antiquarian, classical, and linguistic subjects.

WE have received from our correspondent a full report of the meeting of the German Association at Munich, with important addresses by Prof. Haeckel, "On the Evolution Theory at the Present Day," and by Prof. Nägeli, on the "Limits of Natural Knowledge." Pressure on our space compels us to defer this report till next week.

PROF. J. E. HILGARD, assistant in charge of the United States Coast Survey, has been offered the directorship of the new International Bureau of Weights and Measures in Paris. Prof. Hilgard is one of the excursion party which includes Sir J. D. Hooker, Prof. Asa Gray, and Dr. Hayden.

THE second biennial meeting of the International Congress of Americanists for the discussion of all matters relating to American archaeology, philology, ethnology, and pre-Columbian antiquities generally, was held at Luxemburg on September 10-13. There was a numerous attendance of delegates from all parts of the world. Many papers were contributed to the Congress. Dr. Leemans, Prof. Leon de Rosny, Abbé Pipart, and M. Madier de Montjan, read papers upon primitive American civilisation, and especially picture-writing and hieroglyphics. Several Americans sent communications relative to the mound-builders of the Mississippi valley and the Pueblo Indians of New Mexico; amongst these Messrs. Gillman, of Detroit, Michigan (so well known for his discoveries amongst the burial mounds there), Force, of Cincinnati, and Moody, of Illinois, may be specially mentioned. Dr. Rink contributed a valuable paper upon the primitive habitat of the Esquimaux, maintaining, in opposition to the usual belief, that they came from the interior of America. Messrs. Hyde Clarke and F. A. Allen, of London, contributed essays upon the wider aspect of the question, seeking to trace the civilisation of the primitive races of the New World to a fountain-head in Asia. A valuable paper from M. Lucien Adam furnished a detailed analysis of the grammar of sixteen Indian nations ranging from Lake Athabasca to the Llanos of Brazil. It was resolved by the Congress to memorialise the South American Governments to take steps to preserve authentic records of the language and customs of all small Indian tribes likely soon to become extinct. Throughout the Congress great interest was manifested by the inhabitants in the important subjects discussed, and the visitors were most hospitably entertained by the burgomaster and municipality at a final banquet on Thursday, the 13th, upon which occasion congratulatory telegrams were received from the King of the Netherlands and from Prince Henry, the Governor of the Grand Duchy. It has been decided to hold the third Congress in 1879, at Brussels, when it is hoped the attractiveness and convenience of the locality will induce a larger attendance. The proceedings will be published as soon as possible, and are expected to fill three volumes of 600 pages each.

THE value of the work accomplished by Mr. Stanley, who reports himself on August 10 from Emboma, near the mouth of the Congo, will be universally acknowledged, and there can be but one opinion as to the rank he will hold among geographical explorers. He has solved one of the few great geographical problems which remained for solution, and has performed a feat which baffled even Livingstone's patient genius. Both Livingstone and Cameron had to turn away from Nyangwe on the Lualaba, in Manyuema, foiled in their desire to descend the mysterious river; had Stanley been equally scrupulous no doubt the also would have had to submit to defeat. Determined, however, to trace the course of the river or meet with the fate of

Park, he tells us that partly by marching along the banks, partly by sailing down the river, he traced the course of the Lualaba, changing its name "scores of times," almost direct north from Nyangwe to 2° N. lat., where it turns north-west, then west, then south-west, until as it approaches the Atlantic coast it becomes known as the Kwango or Zaire. Many cataracts had to be passed, and at one of the last of them the remaining one of the Pocock brothers was drowned. The breadth of the stream, Mr. Stanley states, varies from two to ten miles, and in some parts is choked with islands. If we consider Webb's Lualaba as the main stream, then its origin must be regarded as the Chambeze rising to the west of Lake Nyassa, and under many names flowing thence through Lake Bangweola, northwards through Lake Moero, Kowamba, and the reported Kamolondo by Nyangwe to at least 2° N. lat., and thence south-west to the Atlantic Ocean—a course with all its windings, not far short of 3,000 miles. Its basin will thus be included between 32° E. and the west coast of Africa, and 12° S. and 2° N. lat. Its affluents are many, some of them very large. There is the Western Lualaba with its many tributaries, probably the Casai, also with numerous affluents, and very possibly even the Ogovai may be an offshoot from the lower Congo. Between 26° and 17° E. the river has an uninterrupted course, descending thence by about thirty falls and rapids to the great river between the falls of Yellala and the Atlantic. Livingstone heard of a large lake with many islands many miles to the north of Nyangwe, and this may simply be one of the ten-mile wide stretches referred to by Mr. Stanley. Further details will be anxiously looked for, but with our present information we must regard the Congo as one of the largest and most important rivers on the globe. It seems clear that Livingstone was mistaken in connecting the Lualaba with the Nile system. The conduct of Mr. Stanley's expedition it is not our business to criticise; but it seems clear that unless we were prepared to wait for an indefinite period the solution of this important problem and the opening up of undiscovered Africa to commerce and science and civilisation, some pioneer must sooner or later have forced his way through the tribes along the route taken by Stanley. This addition to knowledge has been achieved with much suffering and loss of life, though it seems probable that the many "battles" reported to have been fought may turn out to have been exaggerated in their details. Mr. Stanley was to proceed from Emboma to Cabinda, and thence to St. Paul de Loanda, so that we may soon expect to be able to welcome him home.

IN speaking of the famine in Madras the *Times* Madras correspondent, under date August 29, writes as follows:—"I have not seen Mr. Pogson, the Government astronomer, very lately, but I am informed that he has indicated to the Government the probability of the coming north-east monsoon being a failure also, as the intensity of the solar heat continues unabated. If this be so it is quite impossible to say what the subsequent months will bring forth. The possibility of a great catastrophe such as the failure of seasonal rains at the end of two seasons of scarcity and famine is too horrible to contemplate; but it is in accordance with the history of former famines and the conclusions of scientific men, that rainy seasons in the tropics should be abnormal under the influence of the intense solar heat and the absence of 'spots' on the sun." It is a pity that positive statements like this should be published without reference to any data on which they are based. Had observations on the monsoons been carefully made, tabulated, and worked out for many years past, it would be possible to predict with something like certainty the character of the coming monsoon.

DR. MATTHEWS DUNCAN, of Edinburgh, is to succeed Dr. Greenhalgh at St. Bartholomew's.



DR. WILLIAM STIRLING has been appointed to the chair of physiology in the University of Aberdeen.

THE *American Journal of Pure and Applied Mathematics*, the New York *Nation* states, will appear quarterly, beginning with January, 1878. The form will be quarto, and 384 pages will constitute a volume. The associate-editor in charge is Dr. W. E. Story, Johns Hopkins University, Baltimore.

AT the Social Science Congress which has been meeting in Aberdeen during the past week, there were very few papers of strictly scientific interest. Among papers in the Educational Section was one by Prof. Bain on Competitive Examination for Public Appointments. In their choice of subjects the Civil Service Commissioners had, he remarked, been guided by the received branches of education in the college and schools, but after an inquiry into the essential nature of the subjects, he arrived at the conclusion that the sciences and not the languages were the proper subjects for competition. Other languages than our own were only of secondary utility. He expressed surprise at our intense conservatism in the matter of languages. There were according to him three great regions of study that should be fairly represented by every successful candidate—first, the sciences as a whole; secondly, English composition; and thirdly, institutions and history, with perhaps literature. These he would fix as a minimum. Sir Alexander Grant, principal of the Edinburgh University, read a paper on the Best Means of Securing a High Standard of Education. He considered a revision of the code, in order to remove the inequality in which classics and mathematics stood in relation to science in the "specific subjects," and a reconstruction of the normal school system to be necessary. Dr. Brown, of Haddington, read a paper in which he advocated the establishment of schools of forestry in Great Britain, in view of the fact that all candidates for admission to the department of the Indian Civil Service which had to deal with this matter, had to pass an examination which they at present could only qualify themselves for by going to France or Germany for the instruction. Something of this kind was being attempted in connection with the botanic gardens of the Edinburgh University, where ground had now been acquired for an arboretum.

SOME of our readers may like to know that, as might have been expected, the three rhinoceroses now exhibited in the Alexandra Park are specimens of the African Black Rhinoceros (*Rhinoceros bicornis*). This species is extremely uncommon in menageries, and we have heard of no other in this country except the fine adult male now living in the Zoological Society's Gardens in Regent's Park. The three specimens above referred to are all young, a pair being about eighteen months old, and the other a male not more than a year old. In the larger specimens the posterior horn is much smaller than that upon the nose, whilst in the young male its existence is only indicated by a slight rugosity. The late development of the posterior horn is of particular interest, as it shows that the growth of this dermal appendage is a secondary phenomenon, which makes it not surprising that there may be causes which result in it attaining a greater size than usual, as it does in the so-called distinct species, *R. keitloa*, in which the only characterising feature is its large posterior horn.

It is perhaps a fortunate thing that our great politicians, like the Chancellor of the Exchequer and Mr. John Bright, are beginning to concern themselves in their public addresses with science as well as art. With reference to Mr. Bright's recent address, as the *Times* remarks, if his hearers complain that they have not been told much about either science or art, we can only say that we agree with them, and that we deplore our common loss. In the coming time it is to be hoped that

public speakers, like Mr. Bright, will know better what science really is than they seem to do now.

It is stated that the Italian Government has authorised two officers of the Royal Navy to take part in the Polar expedition which the Swedish Government is fitting out.

THE *Gaulois* states that M. Duruof, the balloonist, has been engaged by the Russian Government to organise an aeronautical service for the Danube army.

THE last field meeting of the Woolhope Naturalists' Field Club for the year will be held at Hereford, for a foray among the funguses, on Thursday, October 4. M. Maxime Cornu, of Paris, is expected to be present. An exhibition of funguses, apples, and pears will be held in the museum room at the Free Library. The fungus foray will be made on the Whitfield Lawns, by the kind permission of the Rev. Archer Clive. Carriages will leave the Free Library at 10 A.M., to return there by 3.30. A meeting of the members will be held on the return, in the Woolhope Room, for the election of officers for the ensuing year, and for the transaction of the ordinary business of the club. After dinner, or in the course of the evening, the following among other papers will be given:—A Report on the Progress of Mycology during the Year, by Dr. Bull; a Report on the Progress of "The Herefordshire Pomona," by the Rev. C. H. Bulmer; "On a Fossil Fungus (*Pythium*) with Zoospores *in situ*, belonging to the Palæozoic Epoch," by Worthington G. Smith, F.L.S.; and if time permit, a paper "On the Mosses of Herefordshire," by the Rev. Augustin Ley.

AT a meeting of the Linnean Society of New South Wales, on March 26, 1877, Mr. E. P. Ramsay read a "Note of a Species of Echidna (*Tachyglossus*) from Port Moresby, New Guinea," in which he described a fine and apparently full-grown male Echidna from that locality, applying to it the specific name *lawesi*, after its discoverer, Mr. Lawes, who had given the specimen to the Museum at Sydney. Mr. Ramsay's description has been published in the *Proceedings* of the above-named Society, and is accompanied by a plate representing the head and forepart of the animal and one of the hind feet, of the natural size. Unfortunately no diagnosis is given whereby the differences between this New Guinean form and the two long-known species of Australia and Tasmania are made plain; but as that gentleman is doubtless familiar with both of them, we may take his word for it that *Tachyglossus lawesi* is a good and distinct species. Its distinctness from the other New Guinean form, *T. brujni*, is manifest.

It has been proposed by a correspondent of the *New York Tribune* to give the names of Romulus and Remus to the two satellites of Mars.

WE understand that the Council of the Working Men's College, Great Ormond Street, have arranged for the ensuing session a series of lectures in connection with the Science and Art Department upon Human Physiology. The lectures will be delivered on Friday evenings by Mr. Thomas Dunman, and will commence on October 5.

AT the meeting of the Birmingham Natural History Society on the 18th inst. Mr. W. R. Hughes, F.L.S., gave some account of the recent dredging excursion of the Society to Arran. He described how the idea of such an excursion took shape, and gave an interesting account of the numerous finds of the party, mainly in Lamlash Bay, where, of course, it was not to be expected that anything new was to be found. Still, many of the forms obtained were of great interest, and the members present gained much solid instruction by being able to examine specimens fresh from their native habitat. Other societies would do well to imitate this enterprising Birmingham association; indeed it might not be a bad idea for several societies to club together

and carry out a similar excursion on a more extended scale. Dr. Marshall described the echinoderms, molluscs, annelids, and crustaceans taken.

PROF. PALMIERI has noted for the present year great anomalies of temperature. The degree of heat observed at the Vesuvius Observatory is unprecedented, having reached  $34^{\circ}\text{C}$ ., and the mercury has fallen as low as  $-7^{\circ}\text{C}$ . This low temperature has never been reached once before, even in January and February, in the twenty-five years during which the observatory has been established.

THE Emperor of Brazil has formed a commission charged with the determination of geographical positions in the empire, and the first work of this commission is just published. It contains an account of the determination of the longitude and latitude of Barra de Pirahy. Geodesic operations are continued for localities situated on the prolongation of the Santos railway, and also on the parallel ( $10^{\circ}$  in length) destined to join Rio to the great meridian of the empire, which will be measured by the commission.

*Die Natur* of September 17 contains an interesting collection of some of the myths and stories which constitute the folk-lore of the Australian aborigines.

IN the Anthropological Section of the Havre meeting of the French Association M. Gustave Lagneau exhibited an ethnographic map of France, on which he has attempted to indicate, in accordance with historical and ethnographical data, the division, juxtaposition, superposition and mixture of the various ethnical elements which have contributed to the formation of the present population of the country.

OF the many natural history societies in the United States but one, so far as is known, is composed almost entirely of Germans, the proceedings of which are published in the German language. This is the Naturhistorisches Verein, of Milwaukee, Wisconsin, of which the annual report for 1876-77 has just been published. This society is organised in five sections—zoology, botany, mineralogy, geology, and ethnology—holds regular meetings, and has quite a large active membership.

A GENERAL inventory has been taken by the French ministry of all the public libraries of France. More than 200 towns have been found to possess each a library numbering from 10,000 to 20,000 volumes.

A SWEDISH paper just received publishes an interesting article under the heading, "Why is the Climate of Europe growing Colder?" The article states that in the Bay of Komenok, near Koma, in Greenland, fossil and very characteristic remains of palm and other trees have been discovered lately, which tend to show that in these parts formerly a rich vegetation must have existed. But the ice period of geologists arrived, and, as a consequence of the decreasing temperature, this fine vegetation was covered with ice and snow. This sinking in the temperature, which moved in a southerly direction, as can be proved by geological data, *i.e.*, the discovery of fossil plants of certain species, seems to be going on in our days also. During the last few years the ice has increased far towards the south; thus between Greenland and the Arctic Sea colossal masses of ice have accumulated. On European coasts navigators now frequently find ice in latitudes where it never existed before during the summer months, and the cold reigning upon the Scandinavian peninsula this summer results from the masses of ice which are floating in the region where the Gulf Stream bends towards our coasts. This is a repetition of the observations made in the cold summer of 1865. The unaccustomed vicinity of these masses of ice has rendered the climate of Iceland so cold that corn no longer ripens there, and the Icelanders, in fear of a coming

famine and icy climate, begin to found a new home in North America.

PROF. NORDENSKJÖLD'S voyages seem to have been of service in opening up a sea-route to Siberia for commerce. A vessel belonging to M. Sidoroff, Capt. Schwanenberg, arrived at Vardö on September 16, after a passage of twenty-one days from the mouth of the Yenisei; and the steamer *Trazer*, belonging to M. Sibiriakoff, Capt. Dahlmann, which sailed from Bremen on July 28 for the mouth of the Yenisei, returned to Hammerfest on September 24.

A FIRE in Washington has destroyed the greater part of the Patent Office Museum, with thousands of patent models, many of great value.

WE notice among Messrs. Churchill's announcements for the forthcoming season: "A Handbook of Analysis of Water, Air, and Food, for the Medical Officer of Health," by Cornelius B. Fox, M.D., M.R.C.P., Medical Officer of Health for Central, East and South Essex; "Parasites: an Introduction to the Study of the Entozoa of Man and Animals, including some Account of the Ectozoa," by T. Spencer Cobbold, M.D., F.R.S., F.L.S., Professor of Helminthology in the Royal Veterinary College; and a "Student's Guide to the Anatomy of the Joints," by Henry Morris, M.A., M.B., F.R.C.S., Assistant-Surgeon to and Lecturer on Anatomy at the Middlesex Hospital.

THE additions to the Zoological Society's Gardens during the past week include a Grivet Monkey (*Cercopithecus griseoviridis*) from West Africa, a Nisnas Monkey (*Cercopithecus pyrrhonotus*) from Nubia, presented by Mr. W. D. James; a Green Monkey (*Cercopithecus callitrichus*) from West Africa, presented by Mr. W. W. Stead; a Macaque Monkey (*Macacus cynomolgus*) from India, presented by Mr. J. F. Greenwood; a Capybara (*Hydrocherus capybara*) from South America, presented by Mr. W. Smith; a Peregrine Falcon (*Falco peregrinus*), European, an African Buzzard (*Buteo tachardus*) from Africa, presented by the Rev. W. Willmott; a West African Python (*Python sibwe*), a Royal Python (*Python regius*) from West Africa, presented by Mr. J. J. Kendall; a Goffin's Cockatoo (*Cacatua goffini*) from the Fiji Isles, an Ariel Toucan (*Ramphastos ariel*), a Maximilian's Aracari (*Pteroglossus wiedi*), two Blue-bearded Jays (*Cyanocorax cyanopogon*), two West Indian Rails (*Aramides cayennensis*) from South America, deposited; two Upland Geese (*Bernicla magellanica*) from the Straits of Magellan, three Andean Geese (*Bernicla melanopectera*), two Slaty Coots (*Fulica ardesiaca*) from Peru, purchased; an Axis Deer (*Cervus axis*), a Yellow-footed Rock Kangaroo (*Petrogale xanthopus*), born in the Gardens.

### THE DIRECT PROCESS IN THE PRODUCTION OF IRON AND STEEL<sup>1</sup>

IN mixing comparatively rich iron ore in powder, with about twenty-five per cent. of its weight of pounded coal, and in exposing this mixture for some hours to the heat of a common stove or of a smith's fire, metallic iron is formed, which, on being heated to the welding point, on the same smith's hearth, may be forged into a horse-shoe of excellent quality. The admixture with the ore of some fluxing materials, such as lime or clay, will, in most cases, be of advantage to rid the iron of adherent slag.

The simplicity of this process is such that it naturally preceded the elaborate processes now in use for the production of iron and steel upon a gigantic scale, nor can it surprise us to find that attempts have been made from time to time down to the present day, to revert to the ancient and more simple method. It can be shown that iron produced by direct process is almost chemically pure, although the ores and reducing agent employed may have contained a considerable percentage of phosphorus,

<sup>1</sup> Some Further Remarks regarding the Production of Iron and Steel by Direct Process. Paper read at the Newcastle Meeting of the Iron and Steel Institute, by C. William Siemens, D.C.L., F.R.S., President.